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CONFERENCE REPORT

Workshop on life cycle sustainability assessment: the state of the art and research needs—November 26, 2012, Copenhagen, Denmark

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1 Introduction

The interest in life cycle sustainability assessment (LCSA) is currently booming in the LCA community, culminating lately in the forthcoming special issue from the *International Journal of Life Cycle Assessment* fully devoted to the topic. In the available literature, LCSA has mainly been conceptualised as a combination of LCA, social life cycle assessment (SLCA) and environmental life cycle costing (LCC).

With the publication of guidelines for performing SLCA (Andrews et al. 2009), the code of practice for LCC (Swarr et al. 2011) and the existing standards for LCA, this could indicate that the question of how to perform an LCSA has been solved. However, the scientific publications give evidence of the need of further discussing the topic, both at conceptual and methodological level.

The topic of LCSA was at the core of a workshop organised on 26th November 2012 in the framework of the SETAC Europe 18th LCA Case Study Symposium in Copenhagen, with a dual aim: (1) to discuss the different schools of thoughts on LCSA and (2) to outline a research agenda framework for enabling/improving LCSA.

The workshop was structured as four sessions (presentations) followed by a discussion part among participants which resulted in the identification of several research areas considered important for the successful future development of LCSA methodology and applications. The presentations provided insights on different approaches to LCSA both at conceptual and methodological level. A short summary of the main conclusions of the presentations and the main research topics proposed during the discussions is explained in the following sections.

2 Workshop presentations summaries

2.1 Frameworks for life cycle sustainability assessment (Walter Klöpffer)

The first conceptualisation of LCSA was presented by Walter Klöpffer from LCA Consult & Review, who reported on the current state of the art. The LCSA framework described can be expressed as LCSA = LCA + LCC + SLCA. In this way, an LCSA requires three separate assessments, one for each sphere of sustainability, where weighing and aggregation should be avoided. Although the framework has been previously

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formalised in a publication (Klöpffer 2008), it was found that there is still a lack of studies reporting the effective use of these tools resulting in holistic LCSA studies, mainly due to the current development state of the methodologies.

Additionally, the importance of the 2011 UNEP/SETAC publication about LCSA was underlined, where a discussion of its methodological foundations and initial case studies regarding the integration of different sustainability measurement tools in a unique sustainability indicator of products or processes is reported (Ciroth et al. 2011).

As an alternative to the standardisation of LCSA as being the sum of LCA, LCC and SLCA, three other possibilities were proposed, so that LCSA could also be in harmony with the ISO standards:

- LCSA = "LCA new". In this case, LCC and SLCA should be included as additional impact categories in the life cycle impact assessment, and as a result, only one life cycle inventory would be defined, which would require revised ISO 14040 + 14044 standards;
- LCSA = Eco-efficiency + SLCA. This proposal, which is built on the new ISO standard on eco-efficiency (ISO International Standards Organization 2012) can be defined as LCA + a "value" component (expressed as a price or LCC result). The addition of SLCA is required to cover social impacts;
- LCSA = LCA + socioeconomic analysis. Framework proposed by the German Institute for Energy and Environmental Research, which is still vague and ambiguous due to the combination of the economic and social spheres being partly defined at present (IFEU 2012).

2.2 Operationalising LCSA (Andreas Jørgensen)

The second presentation was held by Andreas Jørgensen from the Danish Technical University, who argued that, in order to establish a LCSA which can validly assess how products over their life cycle affects sustainability, a starting point should be in a definition of sustainability. As most other researchers within the field of LCSA, the starting point was the so-called Brundtland definition, stating that sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED) 1987). In order to make the definition more operational in an LCSA context, the definition was interpreted as two separate goals:

1. To alleviate poverty in the present generation;
2. To maintain the level of natural, human, social and produced capital constant for future generations.

On the basis of findings from the field of corporate social responsibility research, it was found that the extent to which product life cycles affect poverty in the present generation fit well with impact categories included in presented SLCA methodologies. Furthermore, it was found that the extent to which product life cycles affect the stock of capital can be captured through a slightly modified LCA and SLCA.

The conclusion was that in order to assess the extent to which product life cycles affect sustainability as defined in the "Brundtland definition", a combination of an LCA and SLCA are therefore needed, where the LCA and SLCA methodologies should be revised and expanded in order to account for those aspects that are currently not covered. In short, he therefore argued that LCSA = LCA_{mod} and $SLCA_{mod}$.

In line with this, it was suggested that future research on LCSA should focus on validating the assumed link between product life cycles and impacts on both poverty and the different stocks of capital as well as on establishing indicators in LCA and SLCA for capturing these impact pathways.

2.3 Sustainability assessment of technologies (Lex Roes)

The third presentation by Lex Roes from Utrecht University reported the current results from an EU-funded project named PROSUITE. The project aims to develop a standardised methodology and free software for the evaluation of the sustainability of technologies by using a prospective approach covering environmental, economic and social aspects (PROSUITE 2012). Within this project, five main assessment endpoints have been identified:

- Impacts on human health—more specifically occupational, environmental and consumer health impacts;
- Impacts on social well-being—namely impacts on autonomy, safety, security and tranquillity, equal opportunities, participation and influence;
- Impacts on prosperity—namely labour, capital and resource productivity and new market development;
- Impacts on natural environment—i.e. the ecosystem health;
- Impacts on exhaustible resources—more specifically the fossil resources depletion and the mineral resources usage.

Current discussions within the project partners and among the European Commission are focussed on how it could be possible to consider all the identified indicators in an effective manner in order to provide an evaluation of technologies. In addition, it is under discussion whether there is a need to aggregate the results obtained from the various assessment endpoints or whether it is preferable to leave them as they are.

The main challenges pointed out in the context of the PROSUITE project regard the identification and quantification of social indicators for the well-being assessment endpoint and additionally the definition of the approach to be used to integrate/interpret the endpoint indicators across the environmental, economic and social domains.

2.4 Ontology, epistemology and methodology of LCSA (Alessandra Zamagni)

This presentation focussed on the concept of sustainability science at ontological, epistemological and methodological level (Sala et al. 2012a, b) and presented a framework with suggested methodologies to be used in the context of life cycle sustainability analysis. In this framework, three main needs to contextualise sustainability assessment studies were presented:

- The scope of the indicators, i.e. the three spheres of sustainability;
- "The object of the analysis," from product level up to economy level;
- The mechanisms and relationships relevant to the analysis, besides the technological and environmental ones presently taken into account in LCA.

This transdisciplinary integration framework represents a compendium of models which should be used appropriately on the basis of the scope/scale of the studies and would require a certain level of integration. The most structured approaches available refer to the analysis of products, as there are various types of LCA to evaluate the environmental burdens (e.g. process LCA, environmental input–output LCA), LCC can be used for the economic aspects and SLCA can be adopted to tackle social issues.

Nonetheless, the object of the analysis might increase to a meso-level, by comprising a set of technologies and products. In this case, there would be a need for other models that suit the requirements of the analysis. Environmental input–output analysis (for the environment sphere), input–output analysis and partial equilibrium models (for the economic sphere) could be possible candidates. Lastly, when the subject of the analysis reaches an economy-wide perspective, there is a necessity to develop new models, or possibly to consider the use of multi-region input–output analysis or general equilibrium models (Guineé et al. 2011).

A striking point was that it is very important to be aware of the type of sustainability assessment study to be performed as different types of sustainability questions can be framed (which require different models), and additionally, the scope of the analysis plays a crucial role in the identification of an appropriate approach.

3 Discussion and conclusions

The last part of the workshop was devoted to a discussion session among the participants addressing the question of identifying the most pertinent research needs in relation to the development of LCSA. The discussions were carried out in smaller groups of eight people.

Several groups found that the question of how to communicate the LCSA results was a very relevant research issue to address. A main reason for this seemed to be the fact that the LCSA may include both quantitative and qualitative results (e.g. on social issues) and that considering both types in a decision making context can be difficult. Another point adding to the relevance of this issue was that LCA users often experienced that communicating LCA results could be challenging. By adding new dimensions to the assessment, this challenge was expected to increase.

Another research topic, which was raised by several participants, was the question of how LCSA could actually be put into practice. This question especially referred to the assessment of social aspects included in LCSA, for which data and methods for interpreting results are often lacking.

The importance of involving stakeholders in the evaluation process, in particular in the goal and scope definition, was also acknowledged as relevant by the participants. In fact, this would allow better definition of the system at hand not only in terms of technological relations (i.e. those typically accounted for in any LCA study) but also of values and ethical positions. Such types of relations or mechanisms need to be identified in the analysis, and they become particularly complex to be accounted for when the sustainability assessment is carried out not only at the level of a single product but at higher scales such as sectors/basket of products and/or economy wide. The approaches available in the literature still do not have the capabilities of accounting for such complexities. However, it would be relevant at least to detect and point them out, in order to properly interpret the final results of the assessment.

Overall, the workshop gave the first opportunity to share and discuss the different perspective on LCSA approaches, recognising the need to investigate not only the different methods and models potentially useful for carrying out an LCSA, but to come back to the origins. It is necessary to further investigate the theoretical roots of LCSA, discuss frameworks for LCSA, highlighting their strengths and weaknesses, defining sustainability domains and impact category sets, and properly define the sustainability problem at hand and the connection among the different methods and models that can be used.

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Due to the growing attention towards sustainability issues from a life cycle perspective, there will be a dedicated section to LCSA and SLCA at the 23rd SETAC Europe Annual Meeting, which will be held in Glasgow on May 12–16, 2013.